

Date: 5/04/2013

To: Honorable Rep. Tom McMillin, Chairman , House Committee on Oversight, Michigan Freedom of Information Act, Michigan Legislature

From: Donald Hillman, Ph. D., Professor Emeritus, Michigan State University, East Lansing

Thank You, Mr. Chairman for providing this opportunity to speak to you about the importance of the Freedom of Information Act for the people of Michigan making it less likely for those in Power to Obstruct Justice. I personally became a victim of this power when the Michigan Public Service Commission held a Closed Meeting voting to sequester my articles of research.

I had collected electrical information from farmers whose herds had been affected by stray voltage and had organized the information into three presentations which I presented at MPSC Meetings, administered by ALJ Daniel E. Nickerson, Jr. The meetings were held in Lansing area and Lapeer November 7, 8, and 9, 2005. After the meetings on November 9, the MPSC members who attended held a Secret Meeting of which I received a report in 2009. (See Attached: Secret Meeting of MPSC, 11/09/2005)

In that report Chairman Derkos, was trying to determine the attitude of the members toward my presentations which were all based on farm and published research. Hearing that Dr. Truman Surbrook didn't have any idea about how other frequencies might affect the health of cattle and since he was the Authority, they, under the suggestion of Pete Derkos agreed to seal documents pertaining to my presentations. The other members of the MPSC were deprived of all this Information

### **We Discovered MPSC Uses "Peak" Not "Peak-to-Peak" Measurements.**

After the Hearing of MPSC U-16129, the Tensen Family Farm, which involved testimony from several witnesses, including Electrical Engineer Charles Forster from Wisconsin. I decided to check the Testimony of Douglas Reinneman, a specialist in milking machines from Wisconsin. It was simple, I still had Reinneman's Testimony from Case U-11648 brought by then Attorney General, Frank Kelley. His testimony contained an Exhibit (DJR-26) and ASAE paper 94-3602 which reveals the premeditated choice to use Average Responding "peak" multimeters that measure distorted voltage waveforms resulting in voltage readings that are 25-50% below the True RMS voltage versus measuring "Peak-to-Peak" as confirmed by the Figures attached to Paper No. 94-3602. The decision to consider only steady state was erroneous as were the decisions to measure only 60 Hertz current and to ignore RF and DC (Reinneman's Testimony).

The source was the Wisconsin Stray Voltage Analysis Team (SVAT) whose counseling may have caused Midwest utilities to produce unreliable data and invalid conclusions about electropathic

effects of stray voltage on livestock and humans on farms, homes, schools and other workplaces forcing hundreds of farmers to lose their businesses. We discovered that Barry Kennedy in his *Power Quality Primer, (Kennedy 2000), Chapter 2 and pages 180-184* had understood and attempted to teach the power companies and electricians the difference between peak and peak-peak measurements. We recently published a peer-reviewed article in Elsevier's, *The Total Environment*, and you may each have a copy.

Our surprise was to find that the MPSC continued to use the "Peak" readings in Case U-16129 in 2010, and in the Szymanski Case in 2011.

Using the proper instrument for testing will help to discover the effects of Smart Meters in Detroit and Consumers Energy territory as we have already reported in MPSC 17000 and will disclose whether wind turbines are safe.

Our work is available for your examination.

Donad Hillman, Ph.D., Professor Emeritus (Dairy), Michigan State University, East Lansing.

1                                   **STATE OF MICHIGAN**  
2                   **BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION**

3  
4    In the matter, on the Commission's  
5    own motion, to consider the  
6    implementation of standards or other Case No. U-13934  
7    remedial measures relating to  
8    stray voltage  
9  
10  
11

12                                   **SEALED CLOSED SESSION**  
13                   **SESSION OF THURSDAY, DECEMBER 8, 2005**  
14

15                                   **VOLUME 3**  
16

17   **PRESENT:**  
18

19    Dr. Truman Surbrook, Michigan State University  
20    Jim Schrandt, Michigan State University  
21    Dean Letter, MMPA  
22    Gary Trimmer, MMPA  
23    Steven Wallenwine, Consumers Energy  
24    Pete Derkos, MPSC  
25    Karen Friedline, DTE Energy  
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27  
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31

1 PETE DERKOS - Dr. Surbrook, having seen Dr. Hillman's presentation earlier today  
2 which was very critical of your ability to accurately measure stray voltage, how do you  
3 respond to his allegations that you are not adequately qualified in this field?

4 DR. SURBROOK - Well Pete, Don was correct that I don't have the background like he  
5 does relating to the biological side of this stuff regarding animal or human health.

6 PETE DERKOS - What I meant specifically is Dr. Hillman raised some interesting points  
7 regarding EMF and how these frequencies are outside of the range of normal testing  
8 techniques since normal techniques only measure the 60Hz range.

9 DR. SURBROOK - I have no idea of there are frequencies outside of that range that  
10 would affect animal or human health, all I know is AC current cycles at 60Hz so that's all  
11 I test for and I think that's all anyone should worry about.

12 PETE DERKOS - So is it your suggestion that the Commission discount Don Hillman's  
13 testimony based on the fact that you are not sure what other frequencies there would be  
14 other than 60Hz?

15 DR. SURBROOK - Yes, that would be my recommendation.

16 PETE DERKOS - Does anyone else here in attendance have any comment regarding  
17 support or opposition of this feeling.

18 STEVEN WALLENWINE - I think what Dr. Surbrook says should be considered the  
19 most accurate thing to go on. Besides, Dr. Surbrook is the expert here, I know he's helped  
20 Consumer's Energy out a lot by using his methods to prove that farmers that complain we  
21 are causing stray voltage problems are wrong.

22 DEAN LETTER - I know I took Dr. Surbrook's "Farm Energy Auditor Certification"  
23 course so when it comes to stray voltage what he says should be considered law by the  
24 Commission. Based on my time in Dr. Surbrook's class I know I should trust whatever he  
25 says on the issue of stray voltage.

26 JIM SCHRANDT - I know during my time working in Steve's position at Consumer's we  
27 used Dr. Surbrook on numerous occasions to get us out of stray voltage jams with farms.  
28 One thing the Commission needs to be concerned about is if these farms that complain to  
29 Consumer's about stray voltage are all found to be valid Consumer's will have to sink  
30 millions into equipment upgrades. That cost would have to be passed along to the general  
31 population in the form of higher energy costs. I don't think any of us want some renegade

1 farmer driving up electricity costs for the rest of us. We need to have more people like  
2 Dr. Surbrook out there fighting the good fight for energy companies. I'm sure Karen can  
3 agree with me on this one.

4 KAREN FRIEDLINE - Absolutely Jim, I just wish I had known about Truman sooner.  
5 (attendee laughter)

6 PETE DERKOS - If there is no further discussion I'm going to adjourn here, Truman, I'm  
7 going to recommend to the rest of the Commission that we adopt your proposed  
8 regulations on stray voltage, and also I am going to recommend that we seal documents  
9 pertaining to Don Hillman's presentation or any other correspondence from him.

10 DR. SURBROOK - That sounds good to me, hopefully this will help to finally shut Don  
11 up about this.

12 (attendee laughter)

13 GARY TRIMNER - I have one last question for Truman if that's ok with you Pete.

14 PETE DERKOS - That's fine Gary.

15 GARY TRIMNER - So Truman, lets say we have a farmer that insists he has a stray  
16 voltage problem, you go out there, do your evaluation and determine that he's wrong.  
17 What should we tell him to look at instead of electrical issues if he keeps insisting on  
18 stray voltage being his problem even after you've been there.

19 DR. SURBROOK - Um, tell him to look at other things, tell him his water could be  
20 cleaner, tell him his freestall barns are not clean enough, Try to pass the buck onto the  
21 farmer. 9 times out of 10 the problem is their fault anyway.

22 (attendee laughter)

23 PETE DERKOS - Well lets finally call it a day, I'm ready to get home and eat dinner.  
24 This session is adjourned. Thank you everyone for being here.

25

26

SESSION ADJOURNED 6:32 P.M.

**Paper No. 243602**  
**An ASAE Meeting Presentation**

**CHARACTERISTICS OF COW CONTACT VOLTAGE TRANSIENTS**

by

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and

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**Written for presentation at the**  
**1994 International Winter Meeting**  
**sponsored by**

**THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS**  
**Atlanta, Georgia**  
**December 13 - 16, 1994**

**Summary:**

The Wisconsin Stray Voltage Analysis Team has been collecting data on transient cow contact voltages on Wisconsin dairies since 1989. This paper presents the characteristics of the main categories of transient voltages commonly occurring in dairy barns in Wisconsin. The relationship between transients occurring on the primary distribution system neutral, the farm secondary neutral and on cow contact locations will be discussed. Instrumentation and measurement techniques to determine the source of transient voltages will also be discussed.

**Keywords: Stray Voltage, Measurement**

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## CHARACTERISTICS OF COW CONTACT VOLTAGE TRANSIENTS

### INTRODUCTION

The Public Service Commission of Wisconsin (PSCW) has been doing stray voltage investigations since the early 1980s. In 1987 the PSCW and the Department of Agriculture Trade and Consumer Protection (DATCP) combined resources and conducted a formal investigation of nine farms in Wisconsin in order to report to the Governor and Legislature regarding the extent of stray voltage problems in the state. The "Nine Farm Study" was the basis of legislation that created the Stray Voltage Program at the PSCW. Following enactment of the legislation, the PSCW held statewide public and technical hearings in 1988 that resulted in a formal determination by the Commission known as docket 05-EI-106 (docket 106). Docket 106 established the "level of concern," test procedures and the responsibilities of the state's electric power suppliers in dealing with stray voltage.

Until that time, routine investigations were done primarily by the electric power suppliers with the inevitable concern by some members of the farm community that the testing by the power suppliers was biased. The PSCW with its regulatory authority over the state public utilities was able to establish statewide guidelines for testing and mitigation, resulting in more uniform stray voltage service. The electric Cooperatives, while not under the jurisdiction of the PSCW, agreed to voluntarily comply with docket 106. As part of docket 106, the PSCW established the Stray Voltage Analysis Team (SVAT). One of the SVAT's primary roles was to help farmers who were not satisfied with their power suppliers assessment of their stray voltage concerns. The SVAT was to measure the electrical parameters on the farm and on the distribution system to determine whether or not assessments made by utility investigators were reasonable. An important function of the SVAT included an assessment of non-electric factors that could produce symptoms similar to those of stray voltage.

The SVAT consists of a distribution engineer, an electrical inspector and a veterinarian. The engineer is responsible for reviewing the off-farm distribution system and its impact on stray voltage. The electrical inspector is responsible for reviewing on-farm wiring. The veterinarian is an important member of the team with the ability to assess farm management factors and their impact on animal performance. The SVAT attempts to define both electrical and non-electrical factors that may be impacting the farm operation. The SVAT believes that only a complete assessment of the farm environment and operation can provide the farmer with the tools to improve his operation.

Docket 106 focuses on steady state 60 hertz AC voltages. The "level of concern" established in docket 106 is defined as 1.0 milliamper, 60 hertz steady state Root Mean Square (RMS) current in the cow contact area (0.5 volts across a 500 ohm resistor). Stray voltage is a steady state AC RMS voltage which can be measured between two points which livestock may contact simultaneously. Steady state value is defined as: *"The value of a current or voltage after all transients have decayed to a negligible value"*. Transients are defined as *"changes in the steady state current or voltage caused by faults, operation of protective devices, switching, reclosing,*

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*tap changing, motor starts or stops, motor stalls or other phenomena that are temporary in nature".*

The Public Service Commission of Wisconsin (PSCW) has initiated a new docket, 05-EI-108, which is investigating transient voltages, as well as other electrical phenomenon, in an effort to resolve concerns about perceived electrical problems that exist after stray voltage has been reduced to below the "level of concern". In response to concerns that voltage spikes, transients, or other power quality problems were affecting livestock, the SVAT acquired a Dranetz 658 Disturbance Analyzer as a measuring device to determine if power quality problems associated with power supplier distribution systems were impacting voltages in cow contact areas. Since 1992, the SVAT has used its monitoring equipment to measure both steady state and transient voltages in the cow contact. This paper presents a review of the types of transients that have been observed during SVAT investigations.

## MEASUREMENT INSTRUMENTS AND TECHNIQUES

The measurement circuits used during a SVAT investigation always include the following:

- V<sub>p</sub>** A voltage between the grounded primary neutral at the transformer and a reference rod approximately 150' away. This voltage is measured open circuit.
- V<sub>s</sub>** A voltage between the secondary neutral bus at the barn main service and a reference rod approximately 150' away. This voltage is measured open circuit.
- V<sub>cc</sub>** A voltage at a cow contact point, typically from a water line, stanchion, bunk feeder, or waterer to a copper plate on the floor. This voltage is measured with a 500 ohm shunt resistor.

The equipment listed below monitors and records these voltages. The transients discussed in the paper pertain to these monitoring points. For the purposes of this discussion a transient will be described with the following parameters:

- peak voltage** The maximum voltage of the half cycle having the greatest excursion from zero, either positive or negative (zero to peak),
- phase duration** The time from one zero crossing to the next of one half cycle, and
- event duration** The time during which the voltage is elevated above background levels. The event may contain multiple cycles and will, in general be greater than the phase duration.

The phase duration has been shown to be a critical parameter determining animal sensitivity to peak voltage (Reinemann et al, 1995).

The SVAT uses the Dranetz 658, the WaveRider data acquisition system, the Rustrack Ranger2, and the Kikisui 7100A oscilloscope for recording voltages and currents on the farm. The Dranetz, a four-channel instrument, is used to monitor 120 volt line, primary neutral to earth, secondary neutral to earth and cow contact voltages. It normally samples at a rate of 7200 Hz (120 times per 60 Hz cycle). The present waveform is compared to the previous one to determine if the difference exceeds specified thresholds. If a deviation is found, the sampling rate is increased to 1.8 Megahertz and the event is stored. The Dranetz can capture events down to 1.0 microseconds (frequency response 1.0 Megahertz). The Dranetz also records steady RMS voltages for each channel.

The WaveRider, an eight-channel device, is used to monitor the same three points as the Dranetz plus two additional cow contact voltages and secondary neutral voltage drop (i.e., barn service panel to transformer ground rod). The WaveRider samples at 10,000 Hz across all eight channels, resulting in 250 samples/second on each channel. The WaveRider measures peak voltages and uses this information to calculate RMS voltages and estimated animal contact current assuming that all voltages are sinusoidal with a RMS to peak ratio of 0.707. The WaveRider system interfaces with a laptop computer, where the data is stored and can be reviewed graphically. The SVAT uses the WaveRider System as the main stray voltage analysis tool because of its relatively rapid sampling rate and reliable measurement of the low voltages encountered in stray voltage investigations.

The Rustrack Ranger2, a battery operated, stand alone unit, is used to measure the voltage and currents at the farm transformer secondary. The Ranger2 uses the farm secondary load currents and line voltage to calculate power usage and power factor. The Ranger2 samples at 360 Hz (six times per 60 Hz cycle) and records maximum and minimum values for each channel twice per second. This device provides sufficient resolution to accurately measure motor starting currents. The motor starting currents measured with the Ranger2 and time of the event are compared to both WaveRider and Dranetz data to help identify sources of transient voltages. This data is also used by the SVAT to determine transformer loading and power supplier voltages. While not related to stray voltage, the SVAT insures that the electric service provided meets PSCW rules.

These electrical parameters are monitored for 24 hours. This will encompass at least two milking operations during which time most, if not all, farm electrical equipment will operate. This presents a comprehensive picture of the potential electrical impacts on cows as well as an indication of their source. The SVAT also conducts tests to determine the impact of both primary and secondary neutral voltage drop.

The SVAT also uses a 100-megahertz digital storage oscilloscope to monitor primary neutral, secondary neutral, and cow contact voltages. The oscilloscope is used to view real time voltages and is also useful in finding transients associated with improperly installed electric fences and trainers.

## TRANSIENT VOLTAGE CHARACTERISTICS

A great deal of transient voltage data has been gathered during the SVAT investigations. Initially efforts were focused on determining the types of transients originating on the distribution system which may appear in cow contact areas. Experience has shown that transients appearing in animal contact locations from on-farm sources are more numerous than those from off-farm sources.

A typical cow contact transient ( $V_{cc}$ ) measured between the water line and floor by the WaveRider is illustrated in figure 1. The peak voltage is 0.167 V with an event and phase duration less than 16 milliseconds. Figure 2 shows the same event measured at the secondary neutral ( $V_s$ ). The peak voltage is approximately 1.03 V. The secondary neutral voltage is attenuated by a factor of about ten at the cow contact location.

This same transient event measured at the cow contact point ( $V_{cc}$ ) with a Dranetz is illustrated in figure 3. The Dranetz recorded a peak voltage of 1.9 V and an event and phase duration of approximately 280 microseconds. The peak voltage and phase duration of this transient voltage event were not accurately measured with the WaveRider in the cow contact location. The WaveRider did, however, indicate the presence of a transient voltage.

This particular transient was caused by an improperly grounded fencer. This type of transient cannot be accurately measured with a hand held volt meter. Measurement with an oscilloscope will reveal the presence and specifications of this type of short duration transient voltage.

A similar fencer transient measured at a cow contact location ( $V_{cc}$ ) with an oscilloscope is shown in figure 4. This fencer transient approaches a peak voltage of 20 V. This transient was occurring in cow contact areas once every second. Figure 5 is a time base expansion of Figure 4. The transient pulse is approximately sinusoidal in shape with a phase duration of approximately 50 microseconds. The event duration is approximately 175 microseconds. There are various technologies used for electric fencers and cow trainers. The waveform and pulse width can vary depending upon the different types and settings of the fencers and trainers used. The most common cause for these transients, based on the SVAT experience, is the improper grounding of the electric fencers and trainers. Many are grounded to the water lines in barns or directly to the secondary neutral.

Figure 6 illustrates a transient voltage measured from the secondary neutral to reference rod ( $V_s$ ), with a peak voltage of 12.1 volts and an event duration of approximately 650 microseconds. This same event recorded at the cow contact location ( $V_{cc}$ ) is illustrated in figure 7. The peak voltage has been reduced to 0.7 V with an event duration about 320 microseconds and a phase duration of about 200 microseconds. There is again significant attenuation of the pulse in the cow contact area. Even though this magnitude of voltage at this phase duration is not likely to have significant impact on cows, it is still recommended that the fencer be grounded properly as per manufacturers instructions.

Figure 8 illustrates a transient voltage associated with a faulty SCR dimmer switch. This dimmer switch was located in the farm residence controlling the lights in the dining room and was creating

this transient voltage at the cow contact location. The peak voltage was 6.4 V (12.03 V peak to peak) with an event duration of 11.9 microseconds. The positive peak has a phase duration of approximately 1.0 microseconds. This pulse was not apparent during the normal milking hours testing but appeared in the evening hours when the light in the house was turned on illustrating the value of a 24-hour recording period. The residence was approximately 250 feet away from the monitoring point. This transient will not be perceivable to cows but replacing the dimmer switch removed this source of transient voltage.

Transients can be caused when a motor starts, producing elevated neutral current flow. Significant elevation of the current flow onto the power supplier distribution system neutral is usually the result of a 240-volt motor load. The current flows into the fixed resistance of the distribution system neutral and produces a voltage transient. The voltage magnitude is dependent on the starting current of the motor and the effective impedance of the neutral system. As an example, starting a 10-horsepower motor would draw approximately 250 to 300 amps for several cycles. This would appear on the distribution system as 8 to 10 amps. If the distribution system resistance is 0.5 ohms, a 4 to 5 volt transient would result. In the same way, current flow on the secondary neutral resulting from starting 120 volt motors will produce a transient voltage primarily on the secondary neutral system. The 60:1 transformer ratio for 120 volt load currents makes it unlikely that 120 volt motor starts will appear at significant levels on the primary distribution system neutral. By monitoring the transformer load and neutral currents the source of the transient can be determined.

Figures 9 through 14 show recordings made with the Dranetz, WaveRider and Rustrack Ranger2. This series of figures shows the different equipment capabilities as well as how the information can be used to determine the source of the transient.

A transient voltage recorded on the primary neutral ( $V_p$ ) with the Dranetz is illustrated in figure 9. The peak voltage is 9.3 volts with a phase duration of about 290 microseconds. This type of transient is typical of load switching. The same pulse measured at the secondary neutral ( $V_s$ ) with the Dranetz is illustrated in figure 10. The peak voltage is 7.1 V or about 2.0 volts lower than the primary neutral voltage. The primary ( $V_p$ ) is out of phase with the secondary ( $V_s$ ) voltage, indicating an on farm source. Phase reversal is due to secondary neutral current being drawn out of phase with the primary neutral current. The primary neutral current is in phase with one leg of secondary supply (L1) and out of phase with the other leg (L2).

This same event, measured with the Dranetz in the cow contact location ( $V_{cc}$ ) is shown in figure 11. The peak voltage is reduced to 1.5 V at the cow contact location. The phase duration is approximately 250 microseconds with an event duration in excess of 600 microseconds.

A cow contact transient ( $V_{cc}$ ), measured with the WaveRider, is illustrated in Figure 12. The peak voltage is 0.316 V with a phase duration about 22.5 milliseconds. Figure 13 shows the same event measured on the primary neutral ( $V_p$ ). The duration is the same but the peak voltage is about four times greater, 1.3 V. While the WaveRider may not give a completely accurate measure of peak voltage and phase duration, it is a good indicator of the presence of transients

due to motor starts, indicating that further investigation is required with a higher frequency measurement device.

Measurements of this same event were made simultaneously of the phase and neutral currents at the transformer with the Rustrack Ranger2. Figure 14 shows 3 graphs of current measurements (105 = secondary neutral current, 107 = leg A of secondary load current, 108 = leg B of secondary load current). The transient voltages shown in Figures 12&13 are related to the increase in current on the secondary neutral (105) and leg A of the secondary load (107). A 5-amp transient change in both secondary neutral and load current was measured. This indicates that the source is a 120-volt load. The time of day of this transient event would help the investigator to determine which piece of equipment was the source of this event. The source could be in the barn where animal contact voltages are being measured or could be in another building on the farm or possibly the farm residence. The additional information provided by monitoring the currents at the transformer helps determine the source of the voltage and appropriate methods to reduce this voltage source.

Another transient event is shown as recorded with the Dranetz (Figure 15), WaveRider (Figure 16) and Rustrack Ranger2 (Figure 17). The Dranetz shows a peak voltage peak of 3.25 V with a phase duration of approximately 280 microseconds at the cow contact location (Vcc). Figure 16 shows the same event recorded with the WaveRider at the secondary neutral (Vs) with a peak voltage of 0.098 V. The Ranger2 recorded a 18 A change in secondary neutral current. By cross checking the measurements made with the Dranetz, WaveRider, and Ranger2 the SVAT was able to determine conclusively that this transient event was caused by a faulty 120-volt load in the barn.

SVAT uses a Combined Technologies Ramcorder RC3B to provide details on the activity and characteristics of the primary distribution system neutral. This unit is a stand alone battery operated recorder that is used to measure the primary neutral to reference voltage and primary neutral current approximately 1/4 mile from the farm toward the substation. The unit is connected between the primary neutral and an open ground rod conductor at a pole along the distribution line, to monitor primary neutral to reference voltages. A current transformer is attached to the primary neutral to monitor primary neutral currents. Figures 18 and 19 show typical recordings. The time scale is similar to that in Figures 15-17. A voltage change of 0.2 V is shown in figure 18 with an associated current change of about 1.0 A. The effective distribution system resistance appears as 0.2 ohms at this location. This equipment is not designed to capture fast transient pulses. It is capable of accurately measuring 60 hertz disturbances but cannot accurately characterize transients in excess of several hundred hertz. The measurements on the distribution system help determine the potential impact of primary neutral current loads from other customers, on the farm being investigated. The Ramcorder also allows SVAT to get a good approximation of the effective resistance of the distribution system neutral.

#### Summary and Recommendations

Transient voltages encountered in the field are usually highly damped, biphasic, sinusoidal pulses with frequency ranging from 60 Hz to more than 50,000 Hz. The SVAT uses a number of pieces

of test equipment with which to record transient electrical activity operation on a farm and the interaction of the power supplier's distribution system with it.

The WaveRider is a good tool for measuring stray voltage and provides useful data for motor starts and other events from 1 to 5 cycles of 60 Hz. These transients are one of the most common types encountered at animal contact locations. The peak voltage and phase duration of higher frequency transient voltages may not be accurately measured with the WaveRider but it will indicate the presence of higher frequency transient voltages.

The Dranetz 658 will record higher frequency transients than the WaveRider. The Dranetz is not designed, however, to accurately measure the low voltages associated with a typical stray voltage investigation. Many of the transient events in cow contact are below the manufacturers specified minimum threshold accurately measured with the Dranetz (2.4 V). Additionally, the low RMS voltages recorded during an investigation are at the low end of the Dranetz's capabilities. By itself the Dranetz is not a good tool for stray voltage investigations. SVAT uses the Dranetz as part of an overall review of the electric service to a farm.

The limitations of the Dranetz are overcome by verification with the other test equipment. The oscilloscope is very useful in finding transients associated with higher frequency transients associated with electric fencers and trainers. The SVAT has found that electric fencers and trainers are capable of producing voltages in excess of 20 volts in cow contact. Since hand held volt meters cannot capture these events, customers may be skeptical of their presence. The oscilloscope can provide the proof needed to convince customers of the importance of properly installed electric fencers and trainers.

The SVAT experience with transients leads us to conclude that the main sources of transients originate on the farm being investigated. This is because of the high degree of attenuation of transient voltages as they travel through the grounded neutral system. The source of a transient voltage is, therefore, generally physically close to the area in which it is detected. The magnitude of a 240-V motor starting transient voltage is influenced by the resistance of the distribution system neutral, but the source current originates from on-farm equipment. Maintaining a low steady state RMS cow contact voltage, will help to minimize all types of transients. Low resistance neutral systems, sound electrical connections and maintenance, and extensive grounding including equipotential planes are good ways to mitigate both steady and transient stray voltages.

#### REFERENCES

Reinemann, D.J., L.E. Stetson, N. Laughlin, 1994. Effects of Frequency and Duration on the Sensitivity of Dairy Cows to Transient Voltages, ASAE Paper No. 943597, presented at the International Winter Meeting of the American Society of Agricultural Engineers, Atlanta, Georgia, December 13-16, 1994.